For Publisher's use

PHYSICS POTENTIAL AND THE STATUS OF DØ UPGRADE AT FERMILAB

JAEHOON YU

MS357, FNAL, P.O.Box 500, Batavia, IL60510

The DØ experiment is one of the two collider experiments at Fermilab. The DØ detector is a multi-purpose detector and took its data during Fermilab TeVatron collider run in 1992-1996. Both the DØ detector and the Tevatron accelerator at Fermilab are currently undergoing significant upgrade to extend the reach to new physics and to further probe Standard Model. In this paper, physics potential of the upgraded DØ detector and the upgrade status are discussed.

In the past few decades, Standard Model (SM) has undergone series of tests and has been extremely successful. The theory unifies three of the four known forces in nature and provides mechanism of which masses are generated from. Despite the successes, there are outstanding issues that cannot be explained within the context of current Standard Model framework. Three most outstanding issues are: neutrino masses whose evidence is becoming clearer from neutrino oscillation experiments[1], unobserved Higgs particle[2], the mediator of electroweak symmetry breaking which is the mechanism to generate masses, and the degree of CP violation which has been observed greater than SM prediction[3].

Therefore, the question becomes two fold: whether the SM is the theory of everything but we just did not discover the Higgs particle or the SM is flawed and there are other models that describe nature better and replace the SM. The upgraded TeVatron collider and its detectors could provide answers to two of the three above outstanding questions, Higgs particle and CP violation, in addition to information on physics beyond SM. In this paper, we present the physics potential of the DØ detector[4] and the status of its upgrade[5].

The most recent global Electroweak fits[6] performed by LEP Electroweak Working group presented at this conference put the limits on the SM Higgs mass to be above 113 GeV/c^2. All the evidences point to single neutral Higgs particle with low mass within the SM framework. However, none of the experiments has observed such particle yet.

In addition, there are general arguments for models beyond SM at Electroweak scale (~ 250 GeV). SM fits suggest the new physics is weakly coupled and might be indirectly pointing to supersymmetry (SUSY). On the contrary, all direct searches of SUSY particles have been negative. Searches for SUSY particles at LEP has put limits on super-partner masses; $m_{\tilde{b},\tilde{t}}$, $m_{\tilde{e},\tilde{\mu},\tilde{\tau}}$, $m_{\tilde{\chi}^{\pm}} > 70 \sim 90\mathrm{GeV/c}^2$, and $m_{\mathrm{LSP}} > 36\mathrm{GeV/c}^2$. Similar results are obtained at TeVatron Run I from both DØ and CDF experiments. Despite the fact that the mass limits are getting more stringent, no evidence have been seen from the measurements.

In order to provide extended phase space and to enhance the possibility of inching closer to finding Standard Model Higgs particle, Tevatron accelerator has been upgraded to increase its luminosity by a factor of 10 to $>\sim 10^{32}\mathrm{cm}^{-2}\mathrm{sec}^{-1}$ and the center of mass energy by 10% to 2 TeV, with respect to the previous run. The increase in instantaneous luminosity is going to result in a total integrated luminosity of 2 fb^{-1}/experiment for the first two years of the run, Run IIa, and to ultimately result in over 15 fb^{-1}/experiment in Run IIb that follows Run IIa and that runs till the LHC experiments comes on-line. The increased accelerator capability and the physics goals naturally raise issues for detector upgrade to accommodate the increased event rates, decreased bunch spacing, and the emphasis in physics goals.

In order to provide adequate functionality for observing Higgs particles and CP violating processes, it is absolutely necessary to implement detectors to enhance b-tagging capability. In addition, the detector response must be fast to react to shorter bunch spacing of the Tevatron collider that starts out with 396 ns and will eventually become 132 ns.

The fundamental philosophy of the DØ upgrade is to retain as much of the excellent performance of the original detector, such as calorimetry, as possible. This philosophy increases cost effectiveness of the detector upgrade. The primary change of the detector is in the tracking system. While RunI detector has a drift chamber and a jet chamber vertex tracking system, without a central solenoid magnet, Run II detector has a 2 Tesla super conducting solenoid magnet[7] in the central tracking volume together with a new tracking detector systems.

In order to strengthen displaced vertex detection for b-tagging, a silicon micro-strip vertex detector (SMT)[8] surrounds the interaction region and is read out through the SVX-II chips[9]. The central cylinder of the SMT consists 6 four layer barrels of double and single sided detectors; two in 2 degree and the other two in 90 degree stereo angles. These barrels are interspersed with 12 disks (F-disks). Each F-disk consists of 12 double sided wedge shaped micro-strip detectors that each covers 15 degrees in ϕ. Large angle coverage is obtained by four large diameter disks (H-disks), two on either side of the central barrel-disk cylinder. Each H-disk consists of 24 single sided wedge shaped detectors. The angular coverage of SMT, including the H-disks, extends out to $\eta = \pm 3$. Total number of readout channel of the SMT system is approximately 800,000.

SMT is then surrounded by the central

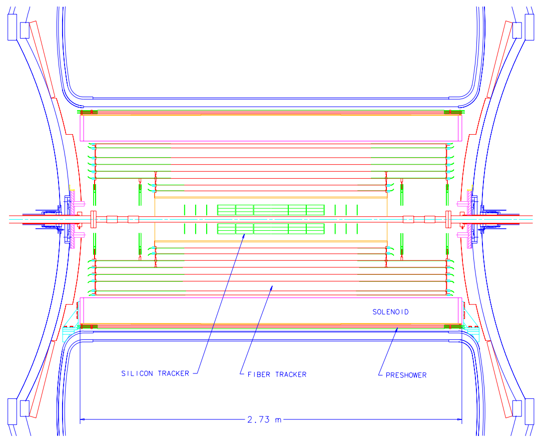

Figure 1. A schematic side view of the upgraded DØ tracking system.

scintillation fiber tracker (CFT)[10] which has a total of 74,000 readout channels. CFT consists of 8 cylindrical layers of scintillating fiber ribbon doublets that cover the directions along the beam and $\pm 5°$ alternate stereo angles with respect to the beam direction. The fibers are read out through low temperature VLPC (Visible Light Photon Counter) readout system whose operating temperature is $\sim 7°$k.

These two central tracking detectors, along with the 2 Tesla solenoid magnet, provide charged particle momentum resolution of $\Delta P_T/P_T \sim 5\%$ at $P_T = 10$GeV/c. Figure 1 shows a schematic side view of the upgraded DØ tracking system.

Since the solenoid has been added to the central tracking system, the total thickness of the material before the electromagnetic section of the calorimeter has been increased by about a factor of two to $\sim 2X_0$. In order to keep the electromagnetic calorimeter energy resolution as good as before, a central and a forward preshower detectors[11] before the first layer of the electromagnetic sections of calorimeters have been added. These preshower detectors consist of scintillation counter strips and $\sim 1X_0$ lead converters, and read out through the same readout chain as CFT. These detectors enable the DØ calorimeter system to retain its energy resolution to within 10% of the original resolution of $\sigma/E = 21\%/\sqrt{E}$. The calorimeter system is currently undergoing an electronics upgrade to sample signal fast to minimize pile-up effects that come from long intrinsic drift time ($\sim 460ns$) liquid argon (LAr).

In addition to the detector upgrade, the DØ experiment upgrades its trigger systems to maximally exploit the improved capability of the upgraded detector. The most important upgrade of the trigger system is the use of CFT and preshower detectors, exploiting quick response time of scintillation light detectors. The muon system also added three layers of scintillation counter layers to enhance muon trigger capability, in addition to upgraded forward muon system. Thick steel shielding blocks have been added on either sides of the muon system, surrounding the beam pipe, to reduce background from beam halo.

As of this conference, more than 90% of the detector construction has been completed, and installation and commissioning have begun since the end of last year. Just before this conference in June, 2000, the DØ central scintillating fiber tracker has been installed into its final position, and wave guide installation has begun. Commissioning effort, thus far, has been concentrated on preparation of DAQ system to adequately support detector debugging and commissioning effort. The DØ experiment is currently planning to begin a cosmic ray commissioning run with all available systems in December, 2000, till before the detector roll-in in January, 2001. This period should provide invaluable opportunity to integrate and to debug the detector system.

In conclusion, Tevatron RunII will provide an order of magnitude higher luminosity at the center of mass energy of 2 TeV and will significantly extend physics reach. This also enables extended search for physics beyond the Standard Model. Currently both accelerator and DØ detector upgrades are progressing well and will be ready for Run IIa which is scheduled to begin March 1, 2001. There is little doubt that the DØ experiment will make a significant impact in understanding of SM and search for new physics beyond SM. The DØ has already started preparing for Run-IIb upgrade, beyond 2fb^{-1} expected from Run-IIa.

References

1. Y. Fukuda *et al.*, Super-Kamiokande Collaboration, Phys. Rev. Lett. **81**, 2561 (1998); Toshiyuki Toshito, in these proceedings (2000)
2. http://lepewwg.web.cern.ch/LEPEWWG/
3. A. Alav-Harati *et al.*, KTeV Collaboration, Phys. Rev. Lett. **84**, 408 (2000); A. Alav-Harati *et al.*, KTeV Collaboration, Phys. Rev. Lett. **83**, 22 (1999)
4. S.Abachi, et al, DØ collaboration,"The DØ detector," Nucl. Instr. Meth. **A338**, 185 (1994).
5. "DØ Upgrade Technical Design Report," DØ Note 2962
6. Bolek Pietrzyk, in these proceedings (2000)
7. "Conceptual Design of a 2 Tesla Superconducting Solenoid for the Fermilab DØ Detector Upgrade," Fermilab TM-1886 (1994)
8. "DØ Silicon Tracker Technical Design Summary," DØ Note 2169 (1994)
9. T. Zimmerman *et al.*, "The SVX II Readout Chip," IEEE Tractions on Nuclear Science, Vol. 42, No. 4, August (1995)
10. M. Atac *et al.*, Nucl. Instrum. Meth. **A320**, 155 (1992)
11. M. Adams *et al.*, Nucl. Instrum. Meth. **A366**, 263 (1995)